EFFECTIVENESS OF THE PLANETARIUM AND DIFFERENT METHODS
OF ITS UTILIZATION IN TEACHING ASTRONOMY

by

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D.L.W.
CHAPTER I

INTRODUCTION

Development of the Planetarium

Men of every civilization have been fascinated by the night sky. Numerous attempts have been made to develop mechanisms which would illustrate celestial objects as well as to demonstrate associated motions. Complex orreys and hollow globes were devised to convey some of these astronomical concepts.\(^1\)

It was not until 1924 that the first planetarium, invented and manufactured by the Zeiss Optical Company of Jena, Germany, made it possible to simulate "the star-studded sky and to bring under control, regardless of the limitations of time, of space, and of weather, the study of many of the stars and their movements".\(^2\)

Large population centers in the United States soon purchased similar instruments. It was here that extensive programs were developed and use of the planetarium was extended into many popular as well as educational fields. Distribution of the instrument was limited considerably by its great expense. Eventually, smaller, more modest


planetariums were invented and manufactured in the United States.\(^3\)

Today, there are several companies with numerous models that are appropriate for use in smaller, local installations.\(^4\)

While renewed interest in earth and space science is having an effect on large planetariums throughout the country, it is exerting an influence on many local school systems. Within the past five years, the planetarium has emerged as an educational facility appropriate for school purchase. At a noticeably increasing rate, city and county school systems are installing their own planetariums.\(^5\)

Astronomical Phenomena Demonstrated by the Planetarium

The planetarium facility is unique in the opportunity that it provides for education in astronomy. The use of star maps or two dimensional visual aids alone cannot illustrate the movements of sun, moon, and planets against the background of stars.\(^6\)

Many astronomical phenomena are so slow in taking place that they are extremely difficult to observe. Examples of this include the big dipper revolving around Polaris, changes in moon positions resulting in different phases, or the seasonal changes in the sky as the earth revolves around the sun.\(^7\)

\(^3\)Ibid.


\(^7\)Russell, op. cit., p. 230.
In addition, coordinates and the meridian can be projected on the celestial sphere. These are invaluable in teaching celestial navigation. The sky as it would appear from the north pole, the equator, or any intermediate latitude can be shown. Constellation study is greatly facilitated by a sky which is always clear. "The experience of studying these phenomena with a planetarium comes so close to being 'real' that the students begin to 'feel' and 'see' the concepts being stressed."^8

**The Planetarium as an Educational Tool**

The planetarium can be a valuable motivating device. A coordinator of one of the major planetariums indicates that one of his major goals is to send students back to the science classroom asking questions, or to the library looking for books to read. He attempts to create an attitude and a desire to learn more of the subject.° Professor Freeman Miller suggests that with its drama, the planetarium often interests people in becoming amateur astronomers and to study the real thing outside of the dome.10

The planetarium has been found to be a valuable teaching aid for even broader application than the typical astronomy unit or class. The

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Elgin Public Schools have found it to be useful for the treatment of mythology in literature, spherical trigonometry in mathematics, terrestrial coordinates in geography, gravitation in the study of physics, and celestial navigation. Even children and adults who are handicapped by deafness, polio, subnormal intelligence, and blindness can benefit from specially prepared planetarium programs. The Argus Planetarium in the Ann Arbor, Michigan, public schools has been used to enrich the programs of some gifted science students. Several of them have given demonstrations and lectures and undoubtedly have been stimulated to learn more astronomy than they otherwise would have.

Increasing Use of the Planetarium in Education

Korey found that the number of planetariums in the United States increased from one, in 1930, to more than 200 by 1963. By that time forty-two states had planetariums and at least twelve new ones were scheduled to open in 1963. By 1967 there were at least 450


planetariums scattered around the country and new ones were opening every week. Even more than half the production of planetariums is for the pre-college educational system. Even so, the widespread adoption of this facility has been long in coming, because it usually requires a special building and relatively expensive equipment.

The Roosevelt, New York, public school district has found that with a 50 per cent contribution from NDEA funds, a twenty-thousand dollar planetarium is still a conspicuous budget item. They, however, have been able to dissolve arguments against it by giving it maximum use. It has been booked solidly days and evenings Monday through Friday and all day Saturday. In addition to use by their own classes, school groups outside the district, public programs for adults, in-service programs for teacher training, and use by amateur astronomy organizations round out the schedule for maximum utility.

An example of extensive use of a planetarium in a public school system can also be observed in the Plymouth Meeting, Pennsylvania, public schools. Their program integrates the use of the planetarium


with certain courses at various grade levels. Approximately half of the lectures are at the fourth, fifth, and sixth grade levels which have a sequence of visits in their astronomy units. In this system, the planetarium director visits each elementary class prior to its first visit to the planetarium. He orients the students and makes an estimate of the level of knowledge of the class as to terms and concepts that will be illustrated in the planetarium. The secondary school program includes use by eighth grade earth science students, by seventh grade geography classes studying longitude and latitude, and by juniors and seniors in an elective course in space science. Even an adult evening astronomy class utilizes the planetarium for half of its class meetings. 19

Pennsylvania had one of the first state-wide programs of earth science at both the elementary and secondary levels. By providing matching funds, the Pennsylvania Department of Public Instruction encouraged schools to establish planetariums and/or observatories. 20 However, results of a questionnaire sent to 545 secondary school districts of Pennsylvania show that thirteen (6.6 per cent) had a planetarium for use in teaching earth-space science, while only four districts (2.0 per cent) had an astronomical observatory. "School officials undoubtedly had some difficulty justifying the expense involved in the building of these costly facilities." The classroom

19 Cross, op. cit., p. 18.

facilities provided by the majority of schools tended to encourage the teacher lecture-demonstration approach and to discourage the laboratory approach in the teaching of earth and space science.21

Evidence of greater interest in the use of the planetarium as an educational device for teaching astronomy can also be observed in the development of published information on this subject. In December of 1963, \textit{The Science Teacher} devoted much of that month's issue to "The Planetarium as an Educational Tool". A series of seven units of study for planetarium offerings for elementary curricula in space exploration has been developed by a Space Science Instructional Materials Project under the support of the National Aeronautics and Space Administration.22

Two symposia have been held concerning "Planetariums and Their Use for Education". The first of these was held at the Cranbrook Institute of Science, in 1958, and the second in 1960 at the Cleveland Museum of Natural History. These meetings reflected the interest of directors of planetariums in meeting the educational needs of school children as well as those of the public.

As Branley suggests, developments in the use of planetariums in public education point to the need for school people and professional

\begin{flushright}
\footnotesize

\textsuperscript{22}The Planetarium: An Elementary School Teaching Resource. Report to the Office of Public Affairs, Educational Programs Division, National Aeronautics and Space Administration, February, 1966.
\end{flushright}
planetarium people to work together to serve the needs of schools more extensively and intensively.\textsuperscript{23}

\textbf{Need for the Study}

Considerable interest and enthusiasm have encouraged use of the planetarium as a teaching device, and teachers have subjectively evaluated its use as a beneficial experience, but very little has been done to test experimentally the value of the planetarium experience or the methods which will result in maximum benefit to students. As is pointed out by Howe:

Dramatically exciting as the use of the planetarium may be, its importance and value as a teaching aid is directly proportional to the degree it helps the teacher accomplish the goal chosen for a particular learning experience.\textsuperscript{24}

Two studies have produced conflicting results as to the value of the planetarium experience for teaching astronomy. Tuttle, in a preliminary study, found that the planetarium significantly aided in the teaching of two and three dimensional concepts; however, in a second study he found no evidence that planetarium classes out-performed classes that did not attend the planetarium.\textsuperscript{25} Smith compared the technique of teaching selected astronomical concepts in a planetarium lecture-demonstration with the technique of teaching the same concepts


\textsuperscript{24}Howe, \textit{op. cit.}, p. 101.

in a classroom lecture-demonstration. His results indicated that sixth
grade students learned the concepts better in the classroom. 26

Chamberlain and Pickering evaluated planetarium demonstrations
with a check-off-type questionnaire completed by teachers. Their
results showed that teachers had the opinion that the lecture-
demonstrations were good and that they were helpful in the related
classwork. 27

These studies underscore the need for further investigation to
provide more conclusive evidence to determine the value of this device.

Common methods accompanying a trip to the planetarium include
preparation before the trip accompanied by follow-up activities. Noble
has recommended that the planetarium lecturer visit the classroom before
the trip for special preparation. 28 But there is no objective evidence
that this procedure is more desirable than having the classroom teacher
provide the preparation.

In studying field trip methods in general, Atyeo states:

Preparatory instruction is an essential of any excursion plan.
It is usually carried on by class discussion supplemented by
projects. The same methods are used in the retrospective study

26Billy Arthur Smith, "An Experimental Comparison of Two Tech-
niques (Planetarium Lecture-Demonstration and Classroom Lecture-
Demonstration) of Teaching Selected Astronomical Concepts to Sixth-
University, 1966).

27Joseph Miles Chamberlain, "The Administration of a Planetarium
as an Educational Institution," (unpublished Ph.D. dissertation,
Columbia University, 1962).

28Margaret Noble, "A Survey of Planetarium Programs," Planetari-
ums and Their Use for Education, Vol. 2 (Cleveland: The Cleveland
of the excursion. The purpose of the preparatory study is to provide a background which will enable pupils to observe carefully and intelligently, and that of the retrospective summing up is to clarify obscure points and to knit the excursion experience firmly into the topic which they were designed to illustrate.

Explanations of exhibits and processes made by teachers who are sufficiently informed are often preferable to those of official guides because of the teacher's acquaintance with pupils' capacities and informational backgrounds.29

Evans developed aids for preparation for a field trip. An evaluation of these indicated that they significantly aided learning as well as retention.30 This conclusion was supported by a study conducted by the New York Port Authority. It was found that students having information on the Port District and the Port Authority before field trips to those facilities performed better on an informational test than did those who had no special preparation.31 No such studies have demonstrated that preparation is equally important to the success of planetarium programs. Follow-up activities have not been evaluated for any type of field trip.

In a study of planetarium practices, Noble observed that elementary children attend in much greater numbers than do secondary school


Reason for this is often related to the problem of scheduling trips in secondary schools which last more than one regular class period. Gilbert concluded from a study of museum trips taken within a single period, that even short trips are beneficial.\textsuperscript{33}

The aforementioned literature indicates the need for objective study of the following questions:

1. Is the planetarium experience valuable in teaching astronomy concepts?

2. Are preparation and follow-up activities essential for a planetarium learning experience?

3. Can the planetarium lecturer prepare a class more effectively for a planetarium program than can the classroom teacher?

4. Does a planetarium trip taken within a single class period provide adequate time for a meaningful learning experience?

For several years, the Ralph Mueller Planetarium in the University of Nebraska State Museum has cooperated with the Lincoln Public Schools in providing a planetarium program as a culminating activity for all eighth grade earth science students in Lincoln. Content of the program was initially developed in a cooperative effort by the Lincoln earth science teachers, the Junior High School Curriculum Coordinator for the Lincoln Public Schools and the Director of the Ralph Mueller Planetarium.

\textsuperscript{32}Noble, \textit{op. cit.}, p. 22.

Planetarium. Each year content and procedures are reviewed and revised by this group. Scheduling has been arranged so the trip can be made within the regular science class period. This situation provided an opportunity to evaluate the planetarium trip as well as methods used in conjunction with it.

**Statement of the Problem**

The purpose of this study was to compare achievement as measured by an Astronomy Achievement Test among eighth grade earth science students of the Lincoln Public Schools who had:

1. Completed an astronomy unit and had not yet attended the planetarium program;
2. Completed an astronomy unit, and attended a planetarium program;
3. Completed an astronomy unit, participated in special preparation conducted by the classroom teacher, attended a planetarium program, and completed a follow-up activity;
4. Completed an astronomy unit, participated in special preparation conducted by the planetarium lecturer, attended a planetarium program, and completed a follow-up exercise.

**Statement of the Null Hypotheses**

**Hypothesis One:** There is no statistically significant difference in achievement as measured by the Astronomy Achievement Test, between (1) students who have attended the planetarium program, and (2) students who have not attended the planetarium program.
Hypothesis Two: There is no statistically significant difference in achievement, as measured by the Astronomy Achievement Test, between (1) students who had special preparation and follow-up activities in connection with the planetarium program, and (2) students who attended the planetarium program with no special preparation or follow-up activities.

Hypothesis Three: There is no statistically significant difference in achievement, as measured by the Astronomy Achievement Test, between (1) students who had special preparation by the classroom teacher before the planetarium program, and (2) students who had special preparation by the planetarium lecturer before the planetarium program.

Definitions

1. Astronomy Achievement Test: W. T. Barnard's seventy-five item true-false test on the "Heavens" combined with five items constructed by a committee of Lincoln eighth grade earth science teachers served as the Astronomy Achievement Test in this study. The committee included three experienced earth science teachers from three different Lincoln junior high schools whose students had participated in the planetarium programs in the past.

2. Field Trip: "Any kind of expedition or trip, definitely organized to achieve certain objectives for young people, and made by a group of students as part of their regular school work." It usually includes three broad phases: (1) preparation, (2) the trip, and (3) the

follow-up study. 35

3. Planetarium: This term which originally referred to the projection instrument has been used in this study to mean the entire installation, including chamber, dome, and the accompanying exhibit and service facilities. The plural form of planetariums has been used in accordance with Webster's Third New International Dictionary. 36

4. Planetarium Chamber: The room which housed the planetarium projector had a rectangular floor plan of approximately fifty-one feet by fifty-one feet. The central portion of the ceiling was composed of a hemispherical, plastered dome thirty-one feet in diameter.

Delimitations

This study is delimited to eighth grade earth science students of the Lincoln Public Schools during the 1966-1967 school year who had completed or nearly completed a six week unit on astronomy.

Achievement in astronomy was measured by a test by W. T. Barnard, "The Heavens", combined with five items constructed by a test committee. This committee included three experienced eighth grade earth science teachers from three different Lincoln junior high schools who had participated in the planetarium programs in the past.

35Atyeo, op. cit., p. 738.

CHAPTER II

REVIEW OF THE LITERATURE

Research Relating to the Planetarium

A careful review of the literature revealed many opinions on the value of the planetarium as a teaching device in astronomy. There were also numerous articles describing new planetarium installations, but very few were found concerning the evaluation of the planetarium as a teaching device. There were no studies of the methods appropriate for use with a planetarium lesson.

In 1963, Korey conducted a questionnaire survey of 203 planetariums in the United States. She found that formal evaluation procedures had not yet been established. Concern for assessment and improvement seemed to be evidenced by planetarium directors, but only informal methods had been used.

Some planetarium lecturers attempted to evaluate the success of a presentation by the "feel" of an audience. A question-and-answer approach was sometimes incorporated, and frequently the extent of comprehension and interest were evaluated from comments and questions after the lecture. Letters of appreciation and pictures drawn by younger children which were sent to the lecturer after visits afforded some insight into children's reactions and impressions. A few planetariums had experimented with short-answer mimeographed questions, but these had been considered learning devices rather than evaluative instruments.
As a result of the responses to the questionnaire, Korey made the following recommendation:

Research is needed to evaluate all phases of class visits to planetariums. So much money has been invested in physical plants and so much time and effort are expended by planetarium and school personnel each time a visit is arranged, that it is essential to discover the most effective way of using the available resources.1

Korey's work indicates that informal approaches have provided only very limited knowledge about the conveyance of astronomical information and concepts in the planetarium. There is still great need for formal objective evaluations of planetarium programs.

Another attempt at assessment of the planetarium program by a questionnaire study was conducted by Chamberlain and Pickering at the American Museum-Hayden Planetarium during the 1959-1960 school year. After planetarium visits, the teachers were asked to complete a brief check-off-type questionnaire. A return of 1,461 questionnaires (72.2 per cent) indicated the following:

1. Lecture materials were considered good by 72.2 per cent of the teachers that reported.

2. Eighty-six and two tenths per cent of teachers considered the method of presentation was "interesting and vivid".

3. Ninety-three per cent indicated that the planetarium visit was helpful in the class work.2

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1Korey, op. cit., pp. 70-72.

In 1960, when the Washington, D.C., public schools were establishing an educational program using the planetarium, Margaret Noble made a foundation supported trip to survey fifteen planetariums in the United States and Mexico. Her conclusions after making this trip included the following opinions: She believed that the class should be studying astronomy when they come to a planetarium, preferably not at the end of their study, so they might extend their learning from the planetarium experience. She felt teachers could derive benefit from in-service study using the planetarium to study astronomy as well as to determine how it could be used with existing science and mathematics curricula. This trip revealed that a follow-through did not seem to be considered in the usual planetarium programming. For preparation before the visit she recommended that the lecturer visit the classroom of the class coming to the planetarium. Noble found that the greatest number of planetarium-goers seemed to be fifth graders, and that elementary school children come in greater numbers than do secondary school children.3

One of the first attempts to objectively evaluate the use of the planetarium in teaching astronomy was made in the Elgin Public Schools by Tuttle in 1964-1965. He taught astronomy units concurrently in two sixth grade classes in which students were matched by I. Q., chronological age, and reading scores. One class was taught only in the planetarium and the other only in the classroom. Pre-tests and post-tests were used to determine gains as measured by the two and three dimension

spatial relations tests from the Multiple Aptitude Test Battery and by a content test constructed by the teacher. Results indicated: (1) a highly significant improvement in three dimension spatial relations at the .01 level, (2) a significance at the .02 level for improvement in two dimension spatial relations, and (3) improvement at the .05 level in gain of content. This would seem to be very impressive evidence in favor of the planetarium.

Since such a small sample was used, Tuttle designed a second experiment for 1965-1966 to evaluate the same factors as well as the importance of frequency of the visits. This study involved 400 sixth grade students who were taught by different teachers using a unit outline to insure uniformity. The content test in this experiment was constructed by the Elementary School Science Project Office. Results of this study indicated no significant difference between any of the factors being considered.

This leaves some confusion as to the reason for the differing results. Tuttle attributed the nonsignificance of the second experiment to the variations in teaching between participating teachers. Tuttle's work leaves room for considerable doubt as to the value of the planetarium experience.⁴

More recently, Smith conducted a study to compare the effectiveness of a planetarium lecture-demonstration with a classroom lecture-demonstration in teaching selected astronomical concepts at the sixth

⁴Tuttle, op. cit.
grade level. The experimental groups, consisting of twelve classes, experienced a forty minute lecture-demonstration concerning selected astronomical concepts in a planetarium. The control group, also twelve classes, experienced a forty minute lecture-demonstration in the classroom including the same astronomical concepts. The investigator conducted all of the lecture-demonstrations and administered objective tests immediately following each lecture-demonstration. The evaluative instrument was an objective, multiple-choice test constructed by the investigator. Analysis of variance was tested with the F-test to reveal a significant difference of achievement favoring the group which experienced the classroom lecture-demonstration.

An evaluative instrument constructed by the investigator may produce results of questionable validity. The assumption that the results are valid for the sixth grade level does not necessarily mean that this finding can be generalized to other grade levels. Smith pointed out the need for further investigation of this problem at the secondary and college levels.\(^5\)

\(^5\) Smith, op. cit., p. 49.
Research Relating to Methods

The professional literature is replete with personal opinions on the value of field trips and with recommendations for procedures to be used in conducting them.

Only two experimental studies have been carried out which attempt to assess the value of special preparation preceding field trips or excursions. None combined the preparation with special follow-up activities. Korey has pointed out the need for study of the degree to which children benefit from preparatory and follow-up activities in addition to planetarium programs.  

In 1955, the New York Port Authority sponsored a study to determine the value of pre-trip classroom information about the port and to assess the value of a harbor inspection tour. A pre-test and post-test design using a test constructed by the Port Authority was applied to three groups. Group A had only study in the classroom; Group B had tour experience only; and Group X had the classroom study preceding the tour. Results indicated that students having any informational experience in the classroom (Groups A and X) had highly significant gains in test scores. Even those having only classroom information made greater gains than those having only the tour. These results may be open to question since classes were not randomly assigned to the three groups. Group A consisted of students who could not go on the trip and the remainder were divided between groups B and X. The construction of the test could

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Korey, op. cit., p. 130.
also contain a bias for the classroom material.\(^7\)

Evans developed aids for field trip planning and carried out an experimental study to assess the value of these aids. Two classes from four grade levels of the Morrison City Public Schools each took two field trips. The two classes at each grade level alternated on the two trips, one class being prepared for the first trip and not for the second and vice versa.

Preparation on the day preceding the trip was in the form of a discussion period conducted by the field trip host. On the day following the trip, tests were administered which had been prepared by the hosts and the researcher. Both groups received a second test two weeks later to determine retention. Three classes served as controls by taking the tests without having taken the trips.

The prepared group scored 33 per cent higher than the unprepared group on the first test. They also scored 35 per cent higher than the unprepared group on the retention test given two weeks later. Control groups scored far below both groups.

These results must also be considered in view of the fact that the field trip host did the preparation as well as constructing the test so it very easily could have been biased for the prepared group.

Evans made the following conclusions:

1. Careful planning preceding a field trip will increase the educational value of the trip.

\(^7\)Cronholm, op. cit., pp. 88-91.
2. Planning not only increases immediate learning, but also aids in retaining materials learned.

3. Bringing field trip hosts into the classroom prior to a field trip, not only increases the educational value of the trip, but also serves to increase mutual understanding and good will between the hosts and the schools.  

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Summary

Since the use of the planetarium as a widely used educational device has been a relatively recent development, there are few studies relating to it. Those that are to be found in the literature are confined to the elementary school level.

Few attempts have been made to assess experimentally the planetarium as a device for teaching astronomy. Tuttle found conflicting results in two studies on this question. Smith produced results which indicated a classroom lecture-demonstration of selected astronomical concepts may be more effective than a planetarium lecture-demonstration of the same concepts. Both investigators used self-designed tests for evaluation, and studied results with sixth grade students. These studies indicate need for further investigation of this question.

Not only did the investigator find no experimental evidence indicating that preparatory and follow-up activities are essential for effective planetarium programs, but it seems there is only scant evidence for this relating to field trips in general. The validity of a study by the New York Port Authority is questionable because of a lack of randomization in the study and because they used a self-designed test.

Evans demonstrates that preparation is very desirable. He concludes, with what seems to this investigator to be inconclusive evidence, that it is more beneficial if done by the field trip host. The investigator found no experimental evidence that follow-up activities are essential even though this is a commonly expressed view.
CHAPTER III

PROCEDURE

Description of Subjects

The subjects participating in this experiment consisted of a total of 1601 eighth grade students enrolled in earth science in the Lincoln Public Schools in the 1966-1967 school year. All eighth grade students in each of the eight junior high schools were required to take this one-semester course; therefore, this population is representative of all groups living in the city of Lincoln, Nebraska. The students who comprised the sample used in this study included twenty-seven of thirty-seven classes from the fall semester, and thirty-two of thirty-four classes from the spring semester.

Description of Measures

No standardized astronomy achievement test appropriate for the junior high level was available in print. After a survey of the literature, a seventy-five item, true-false astronomy test was found to be the only one which was applicable to the junior high level. The author, W. T. Barnard, had given the test to 250 students, and a rights-minus-wrongs scoring formula resulted in a normal distribution of scores. ¹

¹Barnard, op. cit., pp. 605-7.
A committee including three earth science teachers from three Lincoln junior high schools, the Junior High Curriculum Coordinator for the Lincoln Public Schools, and the planetarium lecturer from the Ralph Mueller Planetarium (the investigator) reviewed the test to determine its appropriateness for evaluating achievement for the astronomy unit. The committee's decision was that the test questions reflected content of the astronomy unit as it was being taught; however, they added five items which they felt would make the test more appropriate for this unit. These questions were numbered 76 through 80.2

A rights-minus-wrongs scoring formula was used to determine the final test scores. Tests were scored by hand three times by at least two individuals to insure accuracy.

Description of Research Design and Procedures

The purposes of this study were:

1. To evaluate the effectiveness of the planetarium program as a supplement to the classroom teaching of astronomy.
2. To evaluate the effectiveness of introductory and follow-up materials in combination with the planetarium program.
3. To compare the effectiveness of the introductory materials when presented by (a) the classroom teacher, and (b) the planetarium lecturer.

2 The Astronomy Achievement Test including the five additional questions and the test key are presented in Appendix E.
Design of the Study

To achieve these objectives, it was necessary to use four treatment groups.

Group I. Twenty-seven classes (737 students) were selected at random from those taking earth science in the fall semester, 1966-1967. They represented students from seven of the eight junior high schools. These classes took the Astronomy Achievement Test near the completion of the astronomy unit and on the day immediately preceding their trip to the planetarium. Their test scores indicated achievement as a result of the classroom study without the benefit of the planetarium program.

Group II. Sixteen classes (450 students) were selected at random from those taking earth science in the spring semester of 1966-1967. They represented students of eleven teachers distributed among all eight junior high schools. These classes made the trip to the planetarium at or near the end of the astronomy unit, but they had no special preparation or the follow-up activity. The Astronomy Achievement Test was given to these classes on the day following the planetarium program. These scores indicated achievement as a result of classroom study and the planetarium program.

\[\text{\footnotesize 3}\] The schedule for Group I including classes and teachers is given in Appendix A.

\[\text{\footnotesize 4}\] The schedule for Group II including classes and teachers is given in Appendix A.
Group III. Nine classes (218 students) were selected at random from those taking earth science in the spring semester of 1966-1967. They represented students of nine different teachers distributed among all eight junior high schools. These classes also made the trip to the planetarium at or near the end of the astronomy unit, but the class period immediately preceding the trip was spent in preparation for the trip by the classroom teacher. Each teacher had an outline of the program contents as well as having experienced the program in the past. An outline of topics that should be discussed in the preparation was provided for each teacher. Each student also received a hand-out sheet listing constellations, stars, and questions that would be discussed in the planetarium program. These classes received written follow-up exercises as they left the planetarium. These were to be completed and returned at the beginning of the period on the following day. The class period on the day following the planetarium trip was used to take the Astronomy Achievement Test. These test scores indicated achievement as a result of classroom study, preparation by the classroom teacher, the planetarium program, and the follow-up activity.

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5 The schedule for Group III including classes and teachers is given in Appendix A.

6 The teacher's outline of program contents is presented in Appendix B.

7 The outline of topics for the preparation activity is presented in Appendix B.

8 The hand-out sheet is presented in Appendix B.

9 The written follow-up exercise is presented in Appendix D.
Group IV. Eight classes (196 students) were selected at random from those taking earth science in the spring semester of 1966-1967. This selection was determined in part by the time schedule in that only classes were selected which allowed the planetarium lecturer to do the preparation and to return to the planetarium in time for the programs scheduled for that particular day. These represented classes of eight junior high schools. Preparation for these classes was conducted by the planetarium lecturer using the same outline of topics that were to be discussed by the classroom teachers with Group III. These classes also received the same written follow-up activity as did Group III, to be completed and returned to the classroom teacher at the beginning of the next class period. The Astronomy Achievement Test was administered the day following the planetarium trip. These test scores indicated achievement as a result of classroom study, preparation by the planetarium lecturer, the planetarium program, and the follow-up activity.

Arrangements for the Planetarium Trip

Scheduling of classes and transportation arrangements for the planetarium trip were made by the Junior High School Curriculum Coordinator, Dr. Dale Rathe. Each class was scheduled so the trip could be made within its regularly scheduled earth science class period.

Seating capacity of the planetarium limited attendance at each planetarium lecture to one hundred. One to three classes were scheduled

10 The schedule for Group IV including classes and teachers is given in Appendix A.
for each program. Availability of buses and limited seating in the planetarium necessitated the distribution of planetarium programs over a period of seven school days for Group I and six school days for Groups II, III, and IV.

Preparation of Teachers

1. **Fall Testing.** All eighth grade earth science teachers were notified by the Junior High Curriculum Coordinator that this study would be conducted and be asked for their cooperation. Detailed written instructions were provided each of the teachers who participated in the testing of Group I in the fall.  

2. **Spring Testing.** The eighth grade earth science teachers met at the beginning of the spring semester with the Junior High Curriculum Coordinator and the planetarium lecturer to receive detailed instructions on the remainder of the experiment which involved Groups II, III, and IV. At the time questions were answered and the purposes and procedures of the experiment were clarified. Three teachers who were unable to attend the meeting and the planetarium teacher discussed the experiment on an individual basis.

A written explanation of the study, directions for participating in the study and a schedule of each teacher's part in the study were distributed at the meeting and also accompanied the materials which were distributed to each teacher at the appropriate time.  

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11 Instructions provided for the teachers are presented in Appendix B.

12 Instructions for teachers are presented in Appendix B.
**Preparation Activity**

Each class in Groups II and III was prepared with the aid of an outline which included: general information on the physical conduct of the trip, a description of the planetarium, the sequence of the planetarium program, things to notice in particular, and a vocabulary list of astronomical terms that would be used. The specific manner in which these topics would be discussed was left to the discretion of the individual teacher. All of the teachers had previously attended similar planetarium programs and were therefore familiar enough to answer questions that might arise in the preparation.

Each student in Groups II and III also received a special preparation sheet. This included a list of constellations and stars that would be pointed out as well as the seasons of which they were typical. Each of the names was marked diacritically so the proper pronunciation could be determined. This sheet also contained a list of interest stimulating questions which would be answered in the planetarium program.

**Planetarium Program**

The content of the planetarium program was determined cooperatively by the eighth grade earth science teachers, the Junior High Curriculum Coordinator, and the planetarium lecturer. It included

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13 The outline of topics used for the preparation activity is presented in Appendix B.

14 The student hand-out sheet for preparation is in Appendix B.

15 The script for the tape-recorded planetarium program is in Appendix C.
facts and concepts which could be illustrated most effectively in the three dimensional planetarium chamber with the aid of the special projectors. Emphasis was placed on celestial motions, constellations of the four seasons, the appearance of the night sky from different latitudes, and some principles of celestial navigation.

The planetarium program was tape-recorded by the planetarium lecturer to assure uniformity of content and presentation for all classes participating in the study. Uniformity was further assured since the investigator served as lecturer for all of the programs; operating all visual and sound effects in a similar manner. The program was approximately twenty minutes in length so the classes could travel to and from the planetarium as well as having the program in a single class period.

Follow-up Activity

Only students in Groups III and IV participated in the written follow-up activity. These were distributed immediately following the planetarium program to be used as homework assignments to be returned at the first of the class period on the following day. This procedure enabled these students to take the Astronomy Achievement Test after the same interval of time following the planetarium trip as did Group II. Students were instructed that any reference materials could be used to aid them in completing the questions.

Questions in the follow-up included those that required recall of factual information, deduction from demonstrated astronomical concepts, and personal opinion. A list of references for further study
was also provided. 16

Administration of Astronomy Achievement Test

Group I took the Astronomy Achievement Test on the day preceding their trip to the planetarium while Groups II, III, and IV took it on the day following the trip. Detailed information on the procedure for administering the test was provided for each teacher to insure uniformity. 17 All students were allowed forty minutes to complete the test.

Test papers of those students who missed any part of the program, for which they were scheduled, were discarded.

Since planetarium programs and testing took place over a period of six or seven school days, teachers were asked to indicate to what extent each class had completed the astronomy unit when the tests were administered.

16 The written follow-up exercise is in Appendix D.

17 Instructions for administering the Astronomy Achievement Test are in Appendix E.
CHAPTER IV

FINDINGS AND DISCUSSION

I. Findings

Testing Instrument. The testing instrument was Barnard's seventy-five item true-false astronomy test supplemented by five additional items constructed by a committee of three eighth grade earth science teachers in the Lincoln Public Schools.

Each test paper was hand scored three times by at least two different people to insure accuracy. The number of incorrect responses was subtracted from the number of correct responses, as indicated by Barnard. This rights-minus-wrongs formula adjusted the scores for guessing.¹

Treatment Groups

Four treatment groups were used in this study. Group I included twenty-seven earth science classes who took the Astronomy Achievement Test at the completion of the astronomy unit, but before attending the planetarium. Group II included sixteen classes who attended the planetarium before taking the Astronomy Achievement Test, but who had no special preparation or follow-up activities. Special preparation by the teacher and a follow-up exercise in addition to the planetarium program

¹Barnard, op. cit., pp. 605-7.
was provided for eight classes in Group III before taking the Astronomy Achievement Test. Group IV had special preparation by the planetarium lecturer and a follow-up exercise in addition to the planetarium program before taking the Astronomy Achievement Test. Henceforth in this chapter, these groups will be referred to as Groups I, II, III, and IV.

The adjusted scores on the individual tests were used to calculate the mean scores for each class. Class mean scores were then used as the basic units for calculating group means for statistical comparisons. Standard Deviations were calculated using the group means.

TABLE I

RANGE OF TEST SCORES FOR FOUR TREATMENT GROUPS

<table>
<thead>
<tr>
<th>Group</th>
<th>No. of Test Items</th>
<th>High Scores</th>
<th>Low Scores</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group I</td>
<td>80</td>
<td>+52</td>
<td>-12</td>
<td>64</td>
</tr>
<tr>
<td>Group II</td>
<td>80</td>
<td>+64</td>
<td>-7</td>
<td>71</td>
</tr>
<tr>
<td>Group III</td>
<td>80</td>
<td>+50</td>
<td>-10</td>
<td>60</td>
</tr>
<tr>
<td>Group IV</td>
<td>80</td>
<td>+61</td>
<td>-8</td>
<td>69</td>
</tr>
</tbody>
</table>

Tables II through V indicate the mean scores for each class, the sum of all scores for each class, the means for each group, and the standard deviation for each group.
### TABLE II
CLASS MEANS, SUMS, GROUP MEANS AND STANDARD DEVIATION OF TEST SCORES FOR CLASSES IN TREATMENT GROUP I

<table>
<thead>
<tr>
<th>Class</th>
<th>N</th>
<th>$\sum X_I$</th>
<th>$\bar{X}_I$</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-A</td>
<td>28</td>
<td>521</td>
<td>18.61</td>
</tr>
<tr>
<td>I-B</td>
<td>32</td>
<td>511</td>
<td>15.97</td>
</tr>
<tr>
<td>I-C</td>
<td>17</td>
<td>249</td>
<td>14.65</td>
</tr>
<tr>
<td>I-D</td>
<td>28</td>
<td>581</td>
<td>20.75</td>
</tr>
<tr>
<td>I-E</td>
<td>19</td>
<td>287</td>
<td>15.11</td>
</tr>
<tr>
<td>I-F</td>
<td>26</td>
<td>461</td>
<td>17.73</td>
</tr>
<tr>
<td>I-G</td>
<td>24</td>
<td>446</td>
<td>16.58</td>
</tr>
<tr>
<td>I-H</td>
<td>33</td>
<td>830</td>
<td>25.15</td>
</tr>
<tr>
<td>I-I</td>
<td>27</td>
<td>615</td>
<td>22.78</td>
</tr>
<tr>
<td>I-J</td>
<td>32</td>
<td>684</td>
<td>21.37</td>
</tr>
<tr>
<td>I-K</td>
<td>31</td>
<td>706</td>
<td>22.77</td>
</tr>
<tr>
<td>I-L</td>
<td>22</td>
<td>471</td>
<td>21.41</td>
</tr>
<tr>
<td>I-M</td>
<td>17</td>
<td>280</td>
<td>16.47</td>
</tr>
<tr>
<td>I-N</td>
<td>33</td>
<td>743</td>
<td>22.52</td>
</tr>
<tr>
<td>I-O</td>
<td>31</td>
<td>681</td>
<td>21.97</td>
</tr>
<tr>
<td>I-P</td>
<td>32</td>
<td>665</td>
<td>20.79</td>
</tr>
<tr>
<td>I-Q</td>
<td>29</td>
<td>620</td>
<td>21.38</td>
</tr>
<tr>
<td>I-R</td>
<td>33</td>
<td>708</td>
<td>21.45</td>
</tr>
<tr>
<td>I-S</td>
<td>28</td>
<td>573</td>
<td>20.46</td>
</tr>
<tr>
<td>I-T</td>
<td>28</td>
<td>560</td>
<td>20.00</td>
</tr>
<tr>
<td>I-U</td>
<td>26</td>
<td>571</td>
<td>21.96</td>
</tr>
<tr>
<td>I-V</td>
<td>32</td>
<td>819</td>
<td>25.59</td>
</tr>
<tr>
<td>I-W</td>
<td>32</td>
<td>519</td>
<td>16.22</td>
</tr>
<tr>
<td>I-X</td>
<td>21</td>
<td>374</td>
<td>17.81</td>
</tr>
<tr>
<td>I-Y</td>
<td>26</td>
<td>480</td>
<td>18.46</td>
</tr>
<tr>
<td>I-Z</td>
<td>38</td>
<td>656</td>
<td>17.26</td>
</tr>
<tr>
<td>I-AA</td>
<td>27</td>
<td>450</td>
<td>16.66</td>
</tr>
</tbody>
</table>

**Group Mean** 19.77

**Standard Deviation** 2.91

$N$ = Number of students per class.
$\sum X_I$ = Sum of individual test scores.
$\bar{X}_I$ = Mean score of class.
### TABLE III

CLASS MEANS, SUMS, GROUP MEANS, AND STANDARD DEVIATIONS OF TEST SCORES FOR CLASSES IN TREATMENT GROUP II

<table>
<thead>
<tr>
<th>Class</th>
<th>N</th>
<th>$\sum X_{II}$</th>
<th>$\bar{X}_{II}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>II-A</td>
<td>33</td>
<td>784</td>
<td>24.67</td>
</tr>
<tr>
<td>II-B</td>
<td>30</td>
<td>820</td>
<td>27.33</td>
</tr>
<tr>
<td>II-C</td>
<td>32</td>
<td>626</td>
<td>19.56</td>
</tr>
<tr>
<td>II-D</td>
<td>26</td>
<td>550</td>
<td>21.16</td>
</tr>
<tr>
<td>II-E</td>
<td>29</td>
<td>888</td>
<td>30.62</td>
</tr>
<tr>
<td>II-F</td>
<td>27</td>
<td>804</td>
<td>29.78</td>
</tr>
<tr>
<td>II-G</td>
<td>22</td>
<td>562</td>
<td>25.55</td>
</tr>
<tr>
<td>II-H</td>
<td>31</td>
<td>679</td>
<td>21.90</td>
</tr>
<tr>
<td>II-I</td>
<td>24</td>
<td>514</td>
<td>21.42</td>
</tr>
<tr>
<td>II-J</td>
<td>29</td>
<td>711</td>
<td>24.52</td>
</tr>
<tr>
<td>II-K</td>
<td>27</td>
<td>779</td>
<td>28.80</td>
</tr>
<tr>
<td>II-L</td>
<td>26</td>
<td>728</td>
<td>28.00</td>
</tr>
<tr>
<td>II-M</td>
<td>25</td>
<td>669</td>
<td>26.76</td>
</tr>
<tr>
<td>II-N</td>
<td>26</td>
<td>530</td>
<td>20.38</td>
</tr>
<tr>
<td>II-O</td>
<td>35</td>
<td>826</td>
<td>23.60</td>
</tr>
<tr>
<td>II-P</td>
<td>28</td>
<td>591</td>
<td>21.11</td>
</tr>
</tbody>
</table>

Group Mean 24.70  
Standard Deviation 3.44

$N$ = Number of students per class.  
$\sum X_{II}$ = Sum of individual test scores.  
$\bar{X}_{II}$ = Mean score of class.
<table>
<thead>
<tr>
<th>Class</th>
<th>N</th>
<th>Σ $X_{III}$</th>
<th>$\bar{X}_{III}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>III-A</td>
<td>32</td>
<td>805</td>
<td>25.16</td>
</tr>
<tr>
<td>III-B</td>
<td>30</td>
<td>710</td>
<td>23.67</td>
</tr>
<tr>
<td>III-C</td>
<td>16</td>
<td>261</td>
<td>16.31</td>
</tr>
<tr>
<td>III-D</td>
<td>27</td>
<td>670</td>
<td>24.81</td>
</tr>
<tr>
<td>III-E</td>
<td>31</td>
<td>868</td>
<td>28.00</td>
</tr>
<tr>
<td>III-F</td>
<td>30</td>
<td>649</td>
<td>21.63</td>
</tr>
<tr>
<td>III-G</td>
<td>30</td>
<td>877</td>
<td>29.23</td>
</tr>
<tr>
<td>III-H</td>
<td>22</td>
<td>298</td>
<td>13.55</td>
</tr>
</tbody>
</table>

Group Mean 22.79

Standard Deviation 5.11

$N = $ Number of students per class.

$\Sigma X_{III} = $ Sum of individual test scores.

$\bar{X}_{III} = $ Mean score of class.
## TABLE V

### CLASS MEANS, SUMS, GROUP MEANS, AND STANDARD DEVIATIONS OF TEST SCORES FOR CLASSES IN TREATMENT GROUP IV

<table>
<thead>
<tr>
<th>Class</th>
<th>N</th>
<th>( \Sigma X_{IV} )</th>
<th>( \bar{X}_{IV} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>IV-A</td>
<td>31</td>
<td>822</td>
<td>25.87</td>
</tr>
<tr>
<td>IV-B</td>
<td>33</td>
<td>823</td>
<td>24.94</td>
</tr>
<tr>
<td>IV-C</td>
<td>12</td>
<td>199</td>
<td>16.58</td>
</tr>
<tr>
<td>IV-D</td>
<td>19</td>
<td>482</td>
<td>25.37</td>
</tr>
<tr>
<td>IV-E</td>
<td>27</td>
<td>711</td>
<td>26.33</td>
</tr>
<tr>
<td>IV-F</td>
<td>24</td>
<td>705</td>
<td>29.37</td>
</tr>
<tr>
<td>IV-G</td>
<td>21</td>
<td>475</td>
<td>22.62</td>
</tr>
<tr>
<td>IV-H</td>
<td>29</td>
<td>622</td>
<td>21.45</td>
</tr>
</tbody>
</table>

**Group Mean** 24.07

**Standard Deviation** 4.00

\( N \) = Number of students per class.
\( \Sigma X_{IV} \) = Sum of individual test scores.
\( \bar{X}_{IV} \) = Mean score of class.
Analysis of Variance

The one-way analysis of variance statistical technique was utilized to test for significant differences between the means of the four treatment groups.

F ratios were computed using the following formula:

\[
F = \frac{t^2}{s_w^2(n_1 + n_2)n_1n_2} \]

Calculation of Analysis of Variance

The following symbols were used:

1. \(n_j\) = number of classes per treatment group.
2. \(T_j\) = total of mean scores for classes in a treatment group.
3. \(\bar{X}_j\) = mean of scores in a treatment group.
4. \(\bar{X}_{ij}\) = sum of each squared class mean in a treatment group.
5. \(s_w\) = sum of squares within groups.
6. \(s_b\) = sum of squares between groups.
7. \(k\) = number of treatments.
8. \(N\) = number of classes in all four experimental groups combined.
9. \(T\) = total of mean classes in all four experimental groups combined.
10. \(F\) = the value of a ratio between the sum of squares between groups and the sum of squares within groups.
11. \(F'\) = the adjusted F value using Scheffé's formula, \(F' = (k-1)F\).

Table VI presents the sum of class mean scores and the sum of squared class mean scores for classes in Treatment Groups I, II, III, and IV. It is followed by calculation of F ratios and \(F'\) ratios for all possible comparisons.
<table>
<thead>
<tr>
<th>Group I</th>
<th>Group II</th>
<th>Group III</th>
<th>Group IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>$X_{ij}$</td>
<td>$X_{ij}^2$</td>
<td>$X_{ij}$</td>
<td>$X_{ij}^2$</td>
</tr>
<tr>
<td>21.97</td>
<td>482.68</td>
<td>14.65</td>
<td>214.62</td>
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<tr>
<td>20.79</td>
<td>432.22</td>
<td>20.75</td>
<td>430.56</td>
</tr>
<tr>
<td>21.38</td>
<td>457.10</td>
<td>15.11</td>
<td>288.31</td>
</tr>
<tr>
<td>21.45</td>
<td>460.10</td>
<td>17.73</td>
<td>314.35</td>
</tr>
<tr>
<td>20.46</td>
<td>418.61</td>
<td>18.58</td>
<td>345.22</td>
</tr>
<tr>
<td>20.00</td>
<td>400.00</td>
<td>25.15</td>
<td>632.52</td>
</tr>
<tr>
<td>21.96</td>
<td>482.24</td>
<td>22.78</td>
<td>513.93</td>
</tr>
<tr>
<td>25.59</td>
<td>694.85</td>
<td>21.37</td>
<td>456.68</td>
</tr>
<tr>
<td>16.22</td>
<td>263.09</td>
<td>22.77</td>
<td>418.47</td>
</tr>
<tr>
<td>17.81</td>
<td>317.20</td>
<td>21.41</td>
<td>458.39</td>
</tr>
<tr>
<td>18.46</td>
<td>340.77</td>
<td>16.47</td>
<td>271.26</td>
</tr>
<tr>
<td>17.26</td>
<td>297.91</td>
<td>22.52</td>
<td>507.15</td>
</tr>
<tr>
<td>16.66</td>
<td>277.56</td>
<td>18.61</td>
<td>346.33</td>
</tr>
<tr>
<td>15.97</td>
<td>255.04</td>
<td>15.97</td>
<td>255.04</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>$n_j$</th>
<th>27</th>
<th>16</th>
<th>8</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_j$</td>
<td>533.88</td>
<td>395.16</td>
<td>182.36</td>
<td>192.53</td>
</tr>
<tr>
<td>$\bar{X}_{ij}$</td>
<td>19.77</td>
<td>24.70</td>
<td>22.79</td>
<td>24.07</td>
</tr>
<tr>
<td>$\sum X_{ij}^2$</td>
<td>10,782.16</td>
<td>9,950.24</td>
<td>4,364.71</td>
<td>4,760.74</td>
</tr>
<tr>
<td>$\sum X_{ij}$</td>
<td>10,556.59</td>
<td>9,759.46</td>
<td>4,156.89</td>
<td>4,633.47</td>
</tr>
</tbody>
</table>

$T^2/N = 28,817.52$
$\frac{\sum T_j^2}{n_j} = 29,857.85$
$\frac{\sum T_j^2}{n_j} = 29,106.41$
**TABLE VII**  
**SUMS OF SQUARES**

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Sums of Squares</th>
<th>Degrees of Freedom (df)</th>
<th>Variance Estimate</th>
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<td>Between</td>
<td>288.89</td>
<td>(k-1) = 3</td>
<td>96.30 = $s^2_b$</td>
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<tr>
<td>Within</td>
<td>751.44</td>
<td>(N-1) = 55</td>
<td>13.66 = $s^2_w$</td>
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<td>Total</td>
<td>1040.33</td>
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<td>$F = 7.05$</td>
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In Table VIII a summary of the analysis of variance of test scores of students in the four treatment groups has been presented. The variance estimates have been calculated by dividing the sums of squares by the corresponding degrees of freedom. Calculation of the F test is also shown.

**TABLE VIII**  
**ANALYSIS OF VARIANCE FOR DATA**

Tabled values of $F$ were obtained for significance levels of .10, .05, and .01 for $df_1 = k-1$ and $df_2 = N-k$.

Scheffé’s method as described by Ferguson was used to adjust the tabled F values to a more rigorous criterion with regard to the Type I
error (rejection of the null hypothesis when it is true). It will therefore lead to fewer significant differences. Because this is so, Scheffé recommended that a less rigorous significance level, such as the .10 level, may be used. Unequal n's create no special problem with this method and it is not seriously affected by violations of the assumptions of normality and homogeneity of variance unless they are gross. This method has the advantage that it may not only be used to compare means two at a time, but can be used to make any comparisons at all, including combined groups.

Scheffé's adjusted value of $F$, $F^*$, is $(k-1)$ times the $F$ value required for significance at the desired significance level, that is, $F^* = (k-1)F$.²

Table IX gives the tabled values of $F$ and the values of $F^*$ for different significance levels.

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<th>Significance Level</th>
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<th>Scheffé's $F^*$ Value</th>
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<td>4.16</td>
<td>12.48</td>
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<td>.05</td>
<td>2.78</td>
<td>8.34</td>
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<tr>
<td>.10</td>
<td>2.19</td>
<td>6.63</td>
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### TABLE X

**Comparison of Group Means and Significance Levels of F Test and of Scheffe's Test**

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<tr>
<th>Groups Compared</th>
<th>Calculated F Value</th>
<th>Tabled F Value Level of Significance</th>
<th>Scheffe's F Value Level of Significance</th>
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<td>.01</td>
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<td>Group II with IV</td>
<td>.16</td>
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<td>Group III with IV</td>
<td>.48</td>
<td>not significant</td>
<td>not significant</td>
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<td>Group I with II, III, IV</td>
<td>18.40</td>
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<td>.01</td>
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<td>Group II with III, IV</td>
<td>.95</td>
<td>not significant</td>
<td>not significant</td>
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3 Calculations of F Values are in Appendix F.
Hypothesis One. The computed F value, 17.87, when comparing the mean of Group I (those not having attended the planetarium) with the mean of Group II (those having only the planetarium program) reveals a highly significant difference at the .01 level of significance for both the F test and Scheffé's test as shown in Table X. That is, there is only one chance out of one hundred that this difference could be caused by chance. Significance at the same level, .01, for both the F test and Scheffé's test was found after computing an F value of 18.40 for the differences of the means of Group I and of Groups II, III, and IV combined. It was observed that the means of all groups attending the planetarium (Groups II, III, and IV) were higher than of Group I which did not have this experience before taking the Astronomy Achievement Test.

The means of Groups III and IV considered separately were not as significantly different from the mean of Group I as was Group II. The difference between Group I and Group IV, with a computed F value of 8.37 was significant at the .01 level with the F test and at the .05 level with Scheffé's more rigorous test. The computed F value comparing Groups I and III is only 4.13 which is significant at the .05 level for the F test and is not significant for Scheffé's test.

These results indicate that the null hypothesis, there is no significant difference in achievement as measured by the Astronomy Achievement Test between (1) students who have attended the planetarium program, and (2) students who have not attended the planetarium program, is rejected.
Hypothesis Two. The differences in the achievement of those having preparation and follow-up activities accompanying the planetarium program (Groups III and IV) as compared with those experiencing only the planetarium program can be seen by comparing the mean of Group II with Group III and with Group IV and by comparing the mean of Group II with the combined mean of Groups III and IV.

A computed F value of 1.43 showed no significant difference between the means of Groups II and III and the insignificant computed F value of .16 was found when comparing the means of Group II and Group IV. The combined means of Groups III and IV resulted in an F value of .95 when compared with the mean of Group II.

The results in Table X indicated that there is not a significant difference even at the .10 level between the means of any of these comparisons with either the F test or Schefte's test. Therefore, the null hypothesis, there is no statistically significant difference in achievement, as measured by the Astronomy Achievement Test between (1) students who had special preparation and follow-up activities in connection with the planetarium program, and (2) students who attended the planetarium program with no special preparation or follow-up activities, is accepted.

Hypothesis Three. A comparison of the means of Groups III and IV indicates no significant difference using the F test or Schefte's test in the performance on the Astronomy Achievement Test between those who had been prepared by the teacher and those who had been prepared by the planetarium lecturer. A computed F value of .48 was obtained when means
of the two groups were compared.

The hypothesis, there is no statistically significant difference in achievement as measured by the Astronomy Achievement Test between (1) students who had special preparation by the classroom teacher before the planetarium program, and (2) students who had special preparation by the planetarium lecturer before the planetarium program, is accepted.
II. Discussion

Hypothesis One. The significant difference at the .01 level which was found between the means of Group I and Group II as well as between Group I and Groups II, III, and IV combined seem to indicate that the planetarium can be useful in teaching astronomy.

One might expect that differences between the means of Group I and Groups III and IV considered separately might also be significant; however, the results of this study indicate that they were not significant at the same level. Group IV was significantly different at the .01 level with the F test and at the .05 level with Scheffé's test.

The smaller number of classes, eight, in Group IV could account for this slightly lower significance.

The mean of Group III as compared with the mean of Group I was significantly different at the .05 level only with the F test. There was no significant difference with Scheffé's more rigorous test.

The standard deviation for Group III is 5.11, indicating a greater deviation than is present in the other three treatment groups (see Table IV). This deviation results from one of the eight classes in Group III having an exceptionally low mean of 13.55 which is 9.24 points below the group mean. This single class mean reduces the group mean by 1.32 points. If this class were omitted, the group mean would be 24.11 which is more similar to the means of Groups II and IV and would be significantly different from the mean of Group I. This class mean is the lowest one found in any of the four treatment groups. This unusually low scoring group may have resulted from the fact that while classes were
randomly assigned to treatment groups, students were not necessarily assigned randomly to classes. As was the case with Group IV, the small number of classes, eight, may also account for the critical effect of this low mean score.

The higher performance on the Astronomy Achievement Test by the group experiencing the planetarium program seems to confirm, in objective terms, the opinion of the eighth grade earth science teachers that this was a beneficial activity. However, the question could be raised as to whether the gain on the Astronomy Achievement Test of those attending the planetarium was sufficient to compensate for the effort involved in planning the trip. Consideration should be given to the fact that this Astronomy Achievement Test was largely one involving recall of factual information. No attempt was made to consider understanding of two or three dimensional concepts, changed attitudes, or increased interest or motivation in the field of astronomy.

**Hypothesis Two.** The preparation and follow-up activities did not improve achievement significantly on the Astronomy Achievement Test. Perhaps much of the time devoted to these activities which typically accompany field trips could be more profitably spent. It may be that the Astronomy Achievement Test did not evaluate the types of learning benefited by these activities. It is also possible that since these earth science teachers had attended the planetarium program before, they may have inadvertently prepared students for the planetarium experience throughout the astronomy unit.
Hypothesis Three. The lack of difference in the two modes of preparation may be accounted for by the fact that all of the teachers had previously taken classes to the planetarium for this program, and many had participated numerous times. As a result, the teacher may have had as much information to offer as did the planetarium lecturer. It may also be that familiarity with the class is as important a factor as the lecturer's insights into the program.
CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The Problem

The purpose of this study was to determine if there was a significant difference in achievement as measured by the Astronomy Achievement Test given to eighth grade earth science classes of the Lincoln Public Schools at the completion of an astronomy unit between:

(1) Students who had not attended the planetarium program.

(2) Students who had attended a planetarium program.

(3) Students who had special preparation by the classroom teacher, attended the planetarium program, and had a follow-up exercise.

(4) Students who had special preparation by the planetarium lecturer, attended the planetarium program, and had a follow-up exercise.

Null Hypotheses

The null hypotheses tested were:

(1) There is no statistically significant difference in achievement as measured by the Astronomy Achievement Test between (a) students who have attended the planetarium program and (b) students who have not attended the planetarium programs.

(2) There is no statistically significant difference in achievement as measured by the Astronomy Achievement Test between (a) students who had special preparation and follow-up activities in connection with the planetarium program, and (b) students who attended the planetarium program.
program with no special preparation or follow-up activities.

(3) There is no statistically significant difference in achievement as measured by the Astronomy Achievement Test between (a) students who had special preparation by the classroom teacher before the planetarium program, and (b) students who had special preparation by the planetarium lecturer before the planetarium program.

Procedure

This experimental study compared the achievement on an Astronomy Achievement Test of four groups of eighth grade earth science students: (1) Group I completed an astronomy unit only; (2) Group II completed an astronomy unit, and attended a planetarium program; (3) Group III completed an astronomy unit, had special preparation by the teacher, attended a planetarium program, and had a follow-up exercise; (4) Group IV completed an astronomy unit, had special preparation by the planetarium lecturer, attended a planetarium program, and had a follow-up exercise.

Fifty-nine eighth grade earth science classes in the Lincoln Public Schools participated in the study. Experimental Group I included twenty-seven classes from seven junior high schools in the fall semester. Groups II, III, and IV consisted of 16, 8, and 8 randomly selected classes, respectively. Groups II, III, and IV participated in the spring semester.

The Astronomy Achievement Test consisted of Barnard's 75-item true-false Astronomy Test plus five supplementary items constructed by a committee of earth science teachers. A rights-minus-wrongs scoring
formula was used.

The planetarium lecture was tape recorded and the investigator conducted all programs to insure uniformity of presentation.

The preparation activity was a discussion period on the day preceding the planetarium program. The classroom teachers and the planetarium lecturer used the same outline of topics for discussion. All classes participating in the preparation activity also had a written follow-up exercise.

Results

A one-way analysis of variance with the F test and Scheffé's test was utilized to test for significant differences between the means of the four treatment groups on the Astronomy Achievement Test. The data of this study showed the following results:

(1) There was a statistically significant difference in achievement at the .01 level on both the F test and Scheffé's test between students who had attended the planetarium program and students who had not attended the planetarium.

(2) There was no statistically significant difference in achievement between students who had special preparation and follow-up activities with the planetarium program and those who only attended the planetarium program.

(3) There was no significant difference in achievement as measured by the Astronomy Achievement Test between students who had special preparation by the teacher and those who were prepared by the planetarium lecturer.
Conclusions

1. Eighth grade earth science students in the Lincoln Public Schools who attended a planetarium program made significantly larger gains on an Astronomy Achievement Test than did those who had not attended the program.

2. Eighth grade earth science students in the Lincoln Public Schools did not score significantly higher on an Astronomy Achievement Test when they had preparation and follow-up activities with the planetarium program than those who had only the planetarium program.

3. Eighth grade earth science students in the Lincoln Public Schools who had special preparation by the teacher before the planetarium program did not achieve significantly higher on the Astronomy Achievement Test than did those students who were prepared by the planetarium lecturer before the planetarium program.

4. Eighth grade earth science students of the Lincoln Public Schools can profit from short planetarium programs taken within the regularly scheduled class period.
Recommendations

1. At the eighth grade level, the planetarium should be recognized as a useful device for the teaching of astronomical facts and concepts.

2. Even very short planetarium programs taken within a single class period in secondary schools can be a profitable learning experience in the teaching of astronomy.

3. Preparation and follow-up activities should not be considered to be critical to the usefulness of the planetarium as a teaching device.

4. It should not be considered essential for the planetarium lecturer to visit the classroom to prepare students for a trip to the planetarium.

Suggestions for Further Research

Since the use of the planetarium is a relatively recent method for the teaching of astronomy, a number of fundamental questions need further study. Some suggestions for topics for further investigation include the following:

1. The development and evaluation of different kinds of classroom activity pertaining to the planetarium experience.

2. An evaluation of the effectiveness of tape-recorded lectures as compared to live presentations.

3. A determination of astronomical concepts that can be presented most advantageously in the planetarium and at what grade levels these are most appropriately taught.
4. Determination of whether multiple, short, planetarium programs are more desirable than single, longer ones.

5. To establish how the planetarium might be used to develop interest in astronomy and to motivate outside study.

6. To determine if the planetarium has an influence on vocational or avocational interests.

7. To study facilities that are needed in connection with the planetarium in establishing them in public schools.

8. To develop curricula appropriate for public school systems that have a planetarium.

9. The development of effective standardized evaluative instruments in astronomy.
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Unpublished Materials


# EXPERIMENT SCHEDULE

## FALL, 1966

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APPENDIX B

PREPARATORY MATERIALS
INSTRUCTIONS FOR TEACHERS-FALL, 1966

To the Teacher:

Enclosed are Astronomy Tests which are being used in a study to evaluate the effective use of the planetarium in teaching astronomy at the Junior High level.

Your cooperation in administering this test according to the following instructions will be greatly appreciated. Upon completion of the study, the results for your classes as well as for the entire sample will be provided for you.

If you do not have a sufficient number of tests or if you have questions, please don't hesitate to call me at 477-8711, ext. 2643.

I would appreciate your indicating the extent to which you have completed your astronomy unit at the time that the test is given.

INSTRUCTIONS FOR ADMINISTRATION

This test is to be given at __________ Junior High School
by __________ to _______ classes of eighth grade earth science students on ____________.

Please administer this Astronomy Test during one uninterrupted class period on the date indicated above. Students should be allowed 40 minutes for completion of the test.

Step 1. Distribute test materials.

Step 2. Obtain name, teacher's name, school, class period and sex. Emphasize that they will not be graded on this test, but they should do their best. Please emphasize that they should print their letters clearly.

Step 3. Read aloud the DIRECTIONS printed on the first page of the test.

Step 4. Administer the test according to its specified time limits. (40 min.)


Step 6. Re-seal the tests in the envelope and return them to:

Dr. Dale Rathe
Public School Administration Building
Lincoln Public Schools

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PURPOSES

1. To evaluate the effectiveness of the planetarium program as a supplement to the classroom teaching of astronomy.

2. To evaluate the effectiveness of introductory and follow-up materials in the use of planetarium programs.

3. To compare the effectiveness of the introductory materials when presented by (a) the classroom teacher and (b) the planetarium lecturer.

DESIGN OF THE STUDY - Spring Semester, 1967

<table>
<thead>
<tr>
<th>Completed Astronomy Unit</th>
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<tr>
<td>II. No preparation</td>
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<tr>
<td>II. No Follow-up Exercise</td>
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<td>II, III, and IV Astronomy Achievement Test</td>
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Preparation

Nine different teachers will each prepare one class on the day preceding the trip to the planetarium. These teachers will receive an outline of topics that are to be covered. The manner or extent to which each of these topics is discussed is left to the individual teacher.
The planetarium lecturer (Mrs. Wright) will prepare one class from each of the junior high schools. The outline of topics used by the classroom teachers will also be used by the planetarium lecturer.

Each student will receive a single sheet that is to be used for preparation. It includes the names of constellations and stars of the four seasons that are used in the planetarium lecture. Questions that will serve as guidelines for things to watch for in the planetarium program are also given.

Only those classes designated to receive the preparation are to have this activity. Other classes should in no way be prepared for the planetarium trip.

**Planetarium Program**

The content of the planetarium lecture will be the same as in the past. In order that this content be consistent for all programs this semester, the lecture has been tape-recorded and will be given only by Mrs. Wright.

**Follow-up Exercise**

This is a written exercise that will be done only by those students who also had the preparation. The exercise sheets will be given to the teacher at the planetarium and at the conclusion of the planetarium lecture he or she should give them to each of the appropriate students. They are to be worked out as homework and returned at the beginning of the science period on the next day. They should be collected before the Astronomy Achievement Test is given. No exercises should be accepted after the students have taken the test. The teacher should give no help to students in answering these questions but any other reference materials may be used. Those teachers who come to the planetarium before their regularly scheduled science period should distribute the exercise sheets just before the students leave their class.

**Astronomy Achievement Test**

This test is to be given to all eighth grade science students on the school day following their trip to the planetarium. It should be administered during one uninterrupted class period. Forty minutes should be allowed for completion of the test.
The following steps should be followed in administering the test:

Step 1. Distribute test materials.

Step 2. Obtain name, teacher's name, school and class period.

Step 3. Read aloud the DIRECTIONS printed on the first page of the test.

Step 4. Administer the test according to its specified time limits. (40 min.)


Step 6. Reseal the tests in the container provided along with follow-up exercises.

All follow-up exercises and Astronomy Achievement Tests and preparation materials will be delivered to each school and will be picked up again when the testing is completed for that school.

Please indicate any student who was absent for either the preparation or the follow-up activities.
OUTLINE OF PLANETARIUM PROGRAM
EIGHTH GRADE EARTH SCIENCE STUDENTS

Sundown
- Reds fade first - don't bend well
- Blues bend - twilight

Stars begin to appear
- Appear bright first, then fainter until sky is filled;
- Not millions - 2500 at one time - 5000 throughout year.
- Looks like all stars are same distance away.
- They are not spread evenly - form patterns.

<table>
<thead>
<tr>
<th>Constellations</th>
<th>Bright Stars</th>
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<tbody>
<tr>
<td>Big and Little Dippers</td>
<td>Polaris</td>
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<tr>
<td>Auriga</td>
<td>Capella (yellow)</td>
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<tr>
<td>Gemini</td>
<td>Pollux (Yellow) and Castor</td>
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<td>Taurus (Pleides)</td>
<td>Aldebaron (red)</td>
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<td>Orion</td>
<td>Betelgeuse (red) and</td>
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<td>Rigel (blue-white)</td>
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An overlay projection will indicate the form of the constellation, Orion the Hunter, Index of Winter. Orion's two dogs are indicated by two bright stars, Procyon and Sirius.

Brightest star in the night sky as we see it is Sirius. Distance has a great effect. Sirius is the nearest star that can be seen from Nebraska, it is 7.8 light years or 54 trillion miles away. Rigel is actually brighter but it is 900 light years away. The sun is the closest star; it takes 8 minutes for light to make the trip from the sun to us. (Black light comparing star colors and sizes).

Daily motion is used to point out apparent motion of the circumpolar stars and the rest of the visible sky.

Motion will stop at Spring Sky

<table>
<thead>
<tr>
<th>Constellations</th>
<th>Bright Stars</th>
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<tr>
<td>Leo the Lion (Index of Spring)</td>
<td>Regulus</td>
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<td>Virgo</td>
<td>Spica</td>
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<tr>
<td>Bootes</td>
<td>Arcturus</td>
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<td>Corona Borealis</td>
<td>Gemma</td>
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Move to the Equator (using the Meridian)
Motion at the Equator - notice there are no circumpolar stars.
Will point out Alpha Centuri, Beta Centuri and the Southern Cross.

Return to Nebraska's Summer Sky
Point out the Milky Way - Slide of North American Nebula
Summer Triangle - Index of Summer
Cygnus the Swan
Aquila the Eagle
Lyra the Harp

Move to the North Pole (using the Meridian)
Motion at the North Pole - notice that all stars are circumpolar.

Return to Nebraska's Autumn Sky
Pegasus - Index of Autumn
Andromeda
Cepheus
Cassiopeia

We have seen the sky of all four seasons. Each night we see all of the sky but approximately 30 degrees. We see the same constellations at different times during different months.

Two motions occur as the earth spins and as it revolves around the sun.

Project the coordinate system and explain.

Ecliptic is the apparent path of the Sun, Moon, and Planets.
   A slide will be used to explain this concept.
   Zodiac will be discussed.

Sunrise
TEACHER'S OUTLINE FOR PREPARATION FOR
EIGHTH GRADE PLANETARIUM PROGRAM

SPRING, 1967

(This preparation is to be done only with those classes that are
designated to have the preparation and follow-up exercises in this
research study. This preparation will be done on the day preceding
the trip to the planetarium.)

GENERAL INFORMATION

The planetarium program will be attended during the regular class period
usually.
It will last about 25 minutes.
School buses will transport students to and from school.
There will be other 8th grade science classes in the planetarium at the
same time.
Time is very limited, so maximum cooperation is needed.
All 8th grade science students in Lincoln will be participating in a
research study. Ask for their cooperation.

DESCRIPTION OF THE PLANETARIUM

Discuss the differences between a planetarium and an observatory.
Describe the 30' wide, domed room, theatre seats in concentric circles,
and the projector in the center of the room.
Point out that they should try to orient themselves to the proper
directions in the planetarium.

SEQUENCE OF THE PROGRAM

1. The room will gradually darken, as music plays, so eyes become
adjusted to the dark.
2. Program will begin with identification of constellations and
individual stars of the winter sky at 9:00 p.m.
3. The program will progress through the night skies of all four
seasons at 9:00 p.m. in a similar manner. (Explain how the earth's
revolution makes the stars seem to change positions in various
seasons.)
4. The apparent motion of the stars will be observed from the
equator, from Lincoln, and from the North Pole.
5. The coordinates (celestial lines of location) and the ecliptic will
be discussed and demonstrated in the sky.
6. The sunrise will lighten the planetarium again.
THINGS TO NOTICE

1. The difference in the apparent movement of the stars close to Polaris and those further away.
2. Watch the change in position of the dippers at different seasons.
3. Notice the index constellations of each season.
4. Notice the differences in colors of stars.
5. Notice the brightness of the planets as compared to the stars.
6. Compare the apparent star movements throughout the year with the changes that take place during one rotation (24 hours).

WORDS THAT NEED TO BE UNDERSTOOD

1. Celestial coordinates
2. Celestial meridian
3. Ecliptic
4. Galaxy
5. Light Year
6. Latitude
7. Longitude
8. Magnitude of stars
9. Revolution
10. Rotation
## Constellations and Stars That Will Be Discussed in the Planetarium Program

### Constellations

#### Winter Season
- Orion the Hunter (Index of Winter) (Ori) (Or-ī-on)
- Taurus the Bull (τaur-us)
- Canis Major, the Big Dog (kā-nūs mā-jor)
- Canis Minor, the Little Dog (kā-nūs mi-nor)
- Gemini Twins (jem-ī-nī)
- Auriga the Charioteer (a-rī-ga)
- Ursa Major, the Big Dipper (er-sa mā-jor)
- Ursa Minor, the Little Dipper (er-sa mi-nor)

#### Spring Season
- Leo the Lion (le io) (Index of Spring)
- Virgo (vir-go)
- Boötes the Bear Herder (bō-ō-tēs)
- Corona Borealis (ko-rō-na bo-rē-ā-līs)

#### Summer Season
- Summer Triangle (Index of Summer)
- Cygnus the Swan (sig-nūs)
- Lyra the Harp (lī-ra)
- Aquila the Eagle (ak-wil-a)

#### Autumn Season
- Pegasus the Flying Horse (Index of Autumn) (pe-gā-sus)
- Andromeda the Princess (an-dromē-da)
- Cassiopeia the Queen (kas-ī-o-pē-ya)
- Cepheus the King (sē-fus)

### Stars

- Betelgeuse (bet'-ēl-gōz)
- Rigel (ri-jel)
- Aldebaron (al-deb-ā-ron)
- Sirius (sir-i-ūs)
- Procyon (pro-sē-ōn)
- Castor (cas-tōr)
- Pollux (pō-lūks)
- Capella (ca-pē-lā)
- Polaris (pō-lar-īs)
- Regulus (reg-u-lūs)
- Arcturus (arc-tū-ūs)
- Gemma (gem-ma)
- Deneb (de-neh)
- Vega (ve'-gā)
- Altair (al-tār)

Read these questions and watch for their answers in the Planetarium Program.

1. What makes the stars seem to move across the sky during the night? During the year?
2. Why don’t all stars shine with the same brightness?
3. How does a planet appear to be different from a star in the night sky?
4. Who gave the constellations their names and why were these names selected?

5. At what season can we best see the Milky Way in the early evening?

6. What is the brightest star that can be seen from the earth (excluding the sun)?

7. How are celestial bodies located in the sky?

8. How can latitude be determined using the stars?

9. What is "solar noon"?

10. Where would Polaris be if you were standing at the North Pole? At the Equator?
APPENDIX C

PLANETARIUM LECTURE
Welcome to the Ralph Mueller Planetarium. We are going to use this planetarium to explore the night skies of all four seasons of the year.

If you use your imaginations, perhaps you can imagine that you are seated under the open sky, and as you look around you can see the skyline of Lincoln, Nebraska. In the south is the State Capitol Building; the north is marked by an N; later, you'll see the sun rise in the east; and the stars will seem to set in the west.

MUSIC - FADE LIGHTS - BRING UP STARS

We are going to use our imaginations now to move through time into the evening hour of 9:00 p.m. on this very evening. As light of day fades away you'll see the red glow of evening fading into the blue of twilight.

BRING UP PLANETS - FADE RED LIGHT

The brightest of all planets, Venus, can be seen as a prominent object in the west for about two hours after sunset. Mars can be seen in the east shortly after sunset, and Jupiter is high in the sky.

BRING UP STARS - FADE RED AND BLUE LIGHTS

Now some of the brightest stars can be seen, and then as light fades into darkness, even dimmer stars become visible.

MUSIC

Now you see the stars as they appear to us on this evening at 9:00 p.m. It seems that there are millions of stars in view, but
actually, on a very clear night we can see only about 2500 stars with the unaided eye. Throughout the entire year we see a total of about 5000 different stars.

The stars seem to be scattered at random across the sky, but several thousand years ago, early astronomers grouped the stars into groups around which they drew pictures; these star pictures were called constellations.

Since we are looking at the stars as they appear in the later winter season, we can see the constellations that are typical of winter.

High overhead is the constellation of Orion, the Hunter; he is called the Index of Winter because when we see him overhead in the early evening, it is always the winter season. You can readily identify him by the three stars in a row which mark his belt. His shoulders are here and here, including the giant red star, Betelgeuse. His head is this little group of stars. His legs are here and here, with the brilliant blue-white star, Rigel, in his left knee. With a telescope we could look beyond these visible stars in Orion and see a mass of dust and gases called the Orion Nebula. (SLIDE) Some astronomers believe this is the earliest beginnings of what will become a star.

If we follow a line from the belt of Orion, upward, we find another beautiful red star, Aldebaron, which is the eye of Taurus the Bull. He has a V-shaped face of stars, his horns extend here and here, and on his back is a little cluster of stars, the Pleides. His front legs are here and here. (PROJECT OUTLINE) Perhaps you can see him
better now.

On the other side of Orion, we find two dogs indicated by two bright stars, Sirius is in the Big Dog, Canis Major, and Procyon is in the Little Dog, Canis Minor.

Sirius is the brightest star that can be seen from the Northern hemisphere. Actually, Rigel in Orion, would be much brighter if the two were placed side by side, but Rigel is 900 light years away while Sirius is only 7.8 light years away so it looks much brighter. The closest star is our sun. It takes only eight minutes for its light to reach us.

Castor and Pollux locate the two Gemini Twins and Capella identifies Aurigae the Charioteer.

These bright, first magnitude stars, form a crescent which we call the winter crescent. Now, in the Northern Sky we can find the most familiar of all constellations, the Big Dipper, with the handle and the cup. If you follow a line from the two pointer stars in the cup of the dipper, which are about 5° apart, we’re led to Polaris, our North Star. This is the end of the handle of the little dipper. The handle and the cup are here.

You know that the earth has two motions; rotation, as it spins on its axis each day, and revolution, as it travels in its orbit around the sun each year. As these motions take place, the stars seem to change positions.

MOTION

Throughout the night, you would be able to detect the change in positions of the constellations as you do now. I have speeded time
about 360 times as fast as it usually passes. This motion is a result of the earth spinning on its axis. Since the axis of the earth points directly at the North Star, it seems just to turn in place. Stars around Polaris seem to circle counter-clockwise and thus we call them circumpolar stars. (SLIDE) This shows you the movements of the stars over a period of several hours. Stars further away from Polaris are also inscribing circles around the North Star, but the circles are so much larger that the stars seem to rise in the east, move across the sky, and set in the west. Each twenty-four hours the stars circle once.

STOP MOTION AT SPRING SKY

Now you see stars as we would see them later in this evening or in the spring in the early evening. The Index of Spring is Leo the Lion with the bright star, Regulus. A large question mark of stars represents the head and mane of Leo, his body, tail, and back legs are here.

Beside Leo is a group of stars representing a beautiful maiden named Virgo with long, flowing skirts. Beside Virgo is Bootes, (pause) with the red star, Arcturus. Beside Bootes is a little crown of stars called the Corona Borealis, or the Northern Crown. It has a bright star, Gemmi.

MERIDIAN

Now I'm going to put an imaginary line in the sky called the Meridian. It divides the sky into two equal parts. You can see that the numbers on this line indicate the number of degrees above the horizon. Notice that Polaris is 41 degrees above the horizon. Since we can determine latitude by the angle of Polaris above the horizon, this
tells us that we are at 41 degrees north latitude.

We're going to take a very quick walk to the equator, and as we walk southward, the stars will seem to move northward. (pause) Watch the North Star. (pause) When we finally reach the equator, the North Star will be right on the horizon.

MOTION

If we observe the motion here, you can see that even the stars close to the North Star are rising and setting. At the equator, then, there are no circumpolar stars, they all rise, move across the sky and set. At the equator, in the southern part of the sky, you can see four stars that form the Southern Cross. Beside it are the stars Alpha and Beta Centauri.

Now let's return to Lincoln. This time as we move northward, the stars appear to move southward. Again Polaris is 41 degrees above the horizon.

STOP MOTION

We now see the sky as it appears late in the night or in the Summer Season. Overhead now is the cross-section of our own galaxy, the Milky Way. It contains hundreds of billions of stars so dense and so far away that they appear cloud-like to us. Overhead in this Milky Way, are three bright stars: Vega, Deneb, and Altair. They form what is called the Summer Triangle.

MERIDIAN

Again, let's place the meridian in the sky and this time walk to the North Pole. As we walk northward, Polaris moves higher and higher
in the sky. When we reach the celestial North Pole, Polaris will be directly overhead.

**MOTION**

If we observe the motion from the North Pole, you can see that all stars are circling the North Star. All stars are circumpolar. So, at the equator there are no circumpolar stars, at 41 degrees north latitude some are and some are not circumpolar, and at the North Pole all stars are circumpolar.

**STOP MOTION**

Again, we'll return to Lincoln at 41 degrees north latitude and now we'll see the stars as they appear in the autumn season.

The Index of Autumn is Pegasus, the great Flying White Horse. This square of stars represents the body of Pegasus as he flies through the night sky.

Beside Pegasus is the Princess Andromeda, an A-shaped constellation with three bright stars in a row.

Next to Andromeda is her mother, the Queen Cassiopeia. Some call this the great W in the sky. Beside her, seated on his throne, is the King, Cepheus.

Now we have seen the stars as they appear in all four seasons. During the period of one night we see almost the same stars as the earth spins past them on its axis.

As we look into the night sky, there is a system with which we can locate celestial bodies. This system is called the coordinate system. Imagine that we could project the lines of longitude and
latitude from the earth's surface, out into space. They would look like this.

PROJECT COORDINATES

The horizontal lines are parallel with the equator line which is here. Since our earth is tilted on its axis, these celestial lines of location are at an angle with the orbit of the earth about the sun. (SLIDE) As you can see, this slide shows the orbits of the planets around the sun. This is the plane that the earth seems to move on as it revolves about the sun. It is called the ecliptic. (SLIDE)

Extended into space, it cuts through twelve constellations which are referred to as the twelve constellations of the zodiac. When we look into space, you can see that the ecliptic seems to cut across the coordinates as a result of the different angle. The ecliptic is the path of the sun, moon and all the planets as they seem to travel across the sky in their orbits. In the summer, the ecliptic is higher in the sky and in winter it appears lower. Only twice a year does it fall due east and west. When the sun crosses the meridian, on this ecliptic, it is solar noon.

MOTION

Time has been passing quickly as we have been discussing the stars, and very soon it will be time for the approaching of morning. We have passed through the seasons, but the same changes take place during one night. The stars will begin to fade as light grows brighter in the east. Soon you'll see one of the most beautiful sights of all nature, the Morning Sunrise.

SUNRISE
PLANETARIUM FOLLOW-UP EXERCISE

NAME ___________________________ SCHOOL _______________________

TEACHER ________________________ CLASS PERIOD __________________

DIRECTIONS: Complete the following question or statements as well as you can. You may use your textbook, star charts, or any other references to find the answers. They should be given to students immediately following the planetarium program. They are to be done as homework and returned to the teacher at the beginning of the next science period.

I.

Index of ___________________________ Index of ___________________________

Name of Constellation _____________ Name of Constellation _____________

III.

Index of ___________________________ Index of ___________________________

Name of Constellation _____________ Name of asterism ________________

1. What is the latitude of Lincoln, Nebraska? _____________

2. What is the relationship between stars and nebula? _____________

3. From what place on the earth could you see the maximum number of circumpolar stars _____________ The minimum number? ___________
4. In the celestial coordinates, what are the lines called which correspond to the longitude? ________ To the latitude? ________

5. What three kinds of celestial bodies seem to move across the sky on the ecliptic? ____________, ____________, and ____________?

6. Does the meridian change positions during the night as the stars seem to? __________

7. Why do you think planets were called "wanderers"? _______________

8. If you should wake up in the middle of the night in a different place, how could you tell if you had traveled north or south?

9. List all the factors that you can think of that explain why Betelgeuse and Rigel (both in the constellation Orion) look different from one another.

10. Do you think you can now find some of the constellations that were discussed in the planetarium program? ________ Could you identify more with a star chart? ________

11. If the Big Dipper seems to be standing on its handle at 9:00 p.m. on February 15th, try to estimate what its position would be on the following dates:

<table>
<thead>
<tr>
<th>Positions Through the Year</th>
<th>Positions Through the Night</th>
</tr>
</thead>
<tbody>
<tr>
<td>9:00 p.m. May 15th</td>
<td>9:00 p.m. February 14th</td>
</tr>
<tr>
<td>9:00 p.m. August 15th</td>
<td>3:00 p.m. February 15th</td>
</tr>
<tr>
<td>9:00 p.m. November 15th</td>
<td>9:00 a.m. February 15th</td>
</tr>
<tr>
<td></td>
<td>3:00 a.m. February 15th</td>
</tr>
</tbody>
</table>

What does this tell you about the changes in positions of the stars throughout the year or throughout the 24 hour period?

12. Do you believe that there is much future in studying astronomy? ______

Why or why not? ____________________________
13. What new things did you learn as a result of the planetarium program?

________________________________________________________________________

________________________________________________________________________

14. Do you think the planetarium helped you to understand the apparent movements of stars? ________

15. Would you like to see other planetarium programs? ________

SUGGESTED REFERENCES FOR FURTHER STUDY


APPENDIX E

ASTRONOMY ACHIEVEMENT TEST
INSTRUCTIONS FOR EIGHTH GRADE EARTH SCIENCE TEACHERS

FOR ADMINISTERING THE ASTRONOMY ACHIEVEMENT TEST

Please administer this Astronomy Test during one uninterrupted class period on the date indicated. Students should be allowed forty minutes for completion of the test.

Step 1. Distribute test materials.
Step 2. Obtain name, teacher's name, school, class period and sex. Emphasize that they should print their letters clearly.
Step 3. Read aloud the DIRECTIONS printed on the first page of the test.
Step 4. Administer the test according to its specified time limits. (40 minutes)
Step 6. Re-seal the tests in the envelope and return them to:

Dr. Dale Rathe
Public School Administration Building
Lincoln Public Schools
ASTRONOMY ACHIEVEMENT TEST

DIRECTIONS: In the brackets write T if you know that the statement is true. F if you know that the statement is false. If you do not know whether it is true or false, do not answer.

( ) 1. Our sun is really a star.
( ) 2. No planet may have more than one moon.
( ) 3. Light travels at the rate of 186,000 miles a year.
( ) 4. Venus shows phases just as our moon does.
( ) 5. A light-year is the distance a ray of light would travel in one year.
( ) 6. Radiant energy from the sun does not become light or heat until it strikes something.
( ) 7. It takes about 8 seconds for light to reach us from the sun.
( ) 8. At noon, if one were many miles above the earth's surface, the sky would appear black.
( ) 9. A young star shines white or blue; a middle-aged star yellow; an older star red.
( ) 10. Stars twinkle most near the horizon because the atmosphere the light travels through is there the greatest in depth.
( ) 11. A nebula is a vast gaseous body composed of the stuff from which stars are made.
( ) 12. Sometimes a star may be seen showing between the horns of the crescent moon.
( ) 13. The four principal tools in astronomy are: (a) telescope; (b) mathematics; (c) the spectroscope; (d) the camera.
( ) 14. Astrology is not a true science.
15. It is possible to see clearly with the naked eye several hundred thousand stars at a time.

16. Tides are caused, in part, by the gravitational pull of the moon.

17. Photography reveals millions of stars.

18. To an observer on the moon, the earth would appear as a dazzling planet.

19. The Milky Way Galaxy is composed of billions of stars so far away that we see only their diffused light.

20. The moon shines because it is a luminous body.

21. At the Equator the Pole Star would appear directly overhead.

22. Vision and imagination have no part in the study of astronomy.

23. A good blackboard gives a diffused reflection.

24. Latitude may be obtained by measuring the angle of the Pole Star with the observers' position.

25. A regular reflection requires a smooth surface.

26. The Big Dipper appears to revolve about the Pole Star once every twenty-four hours in a counter-clockwise direction.

27. In general, luminous bodies give out light because they are hot.

28. Any star will arrive at any given point in the sky about four minutes earlier each day.

29. The Big Dipper rises in the east and sets in the west.

30. An object can be seen only when it reflects light, unless the object is itself luminous.

31. Sun spots appear in great numbers at highly irregular intervals.

32. The earth and the moon could be placed, at their proper distance inside the sun and still there would be plenty of space left over.

33. The moon is never blacked out entirely by an eclipse.
( ) 34. The sun rises directly in the east and sets due west twice a year only.
( ) 35. Shadows are longest at noon.
( ) 36. The number of known planets is enormous.
( ) 37. The moon has always the same side turned towards us.
( ) 38. It is solar noon when the sun is directly over some point of the meridian on which one is standing.
( ) 39. Because the sun weighs much more than the earth, the force of gravity on the sun is much less.
( ) 40. The thin crescent following the new moon is seen in the late afternoon.
( ) 41. The solar system consists principally of the sun, the planets and their satellites.
( ) 42. Planets are seen by light reflected from the sun.
( ) 43. A solar eclipse can occur at new moon only.
( ) 44. Between Mars and Jupiter are an enormous number of tiny planets called asteroids.
( ) 45. Planets seem to follow the path of the sun and moon across the sky.
( ) 46. As the moon has no atmosphere, meteors must constantly batter the surface.
( ) 47. The two pointers in the Big Dipper are about 5 degrees apart.
( ) 48. The brightest star in the northern hemisphere is Sirius.
( ) 49. The horns of the crescent following the full moon point east.
( ) 50. The orbit of a planet is in the form of a circle.
( ) 51. Meteors are masses of stone, iron, and nickel.
( ) 52. During the daylight stars are not in that part of the sky that is directly overhead.
( ) 53. There is only one kind of lunar eclipse.
( ) 54. The inclination of the earth's axis partly accounts for the change in seasons.
55. The great size of the rising full moon is explained by the statement that the moon is then closer to the earth.

56. Venus, at its brightest, is the most brilliant of the planets.

57. The moon revolves around the earth once in 29 and 1/2 days.

58. The tail of a comet points always away from the sun.

59. The moon has no atmosphere; therefore sounds are intensified.

60. Light travels in wavy lines.

61. Rays of light reaching us from the sun are parallel.

62. A solar eclipse is caused by the moon coming between the earth and the sun.

63. A lunar eclipse is caused by the moon coming within the earth's annual revolution around the sun.

64. The apparent annual movement of the stars is due to the earth's annual revolution around the sun.

65. The full moon rises at approximately sunset and sets at approximately sunrise.

66. Seas of water occupy part of the moon's surface.

67. The apparent annual path of the sun through the heavens is called the ecliptic.

68. The moon rises approximately 50 minutes later each evening.

69. A comet is a visitor to, not part of, our solar system.

70. A lunar eclipse can occur at any phase of the moon.

71. There are three kinds of solar eclipses.

72. At mid-day on the moon the sky would be black.

73. The temperature on the moon is suitable for human life.

74. The umbra is lighter than the penumbra.

75. A sunset viewed from the moon would be brilliantly colored.

76. Jupiter has three rings encircling it.
( ) 77. Our galaxy is moving toward the star, Vega.

( ) 78. Our galaxy, the Milky Way, is an elliptical galaxy.

( ) 79. Mars is one of the "inner" planets.

( ) 80. Mercury has colder temperatures than any other planet of our solar system.
KEY FOR ASTRONOMY ACHIEVEMENT TEST

2. F  22. F  42. T  62. T  
3. F  23. T  43. T  63. F  
4. T  24. T  44. T  64. T  
5. T  25. T  45. T  65. T  
7. F  27. T  47. T  67. T  
10. T  30. T  50. T  70. F  
12. F  32. T  52. F  72. T  
13. T  33. T  53. F  73. F  
14. T  34. T  54. T  74. F  
15. F  35. F  55. F  75. F  
17. T  37. T  57. T  77. F  
18. T  38. T  58. T  78. F  
20. F  40. T  60. T  80. T  

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APPENDIX F

COMPUTATIONS OF F RATIOS
COMPUTATIONS OF F RATIOS
FOR ALL COMPARISONS

1. Comparison of Groups I and II
\[ F = \left( \frac{X_1 - X_2}{s_w^2/n_1 + s_w^2/n_2} \right)^2 = \left( \frac{\bar{X}_1 - \bar{X}_2}{s_w^2(n_1 + n_2)/n_1 n_2} \right)^2 \]
\[ F = \frac{(19.77 - 24.70)^2}{13.66(27 + 16)/432} \]
\[ F = \frac{24.30}{587.38/432} \]
\[ F = 17.87 \]

2. Comparison of Groups I and III
\[ F = \left( \frac{X_1 - X_3}{s_w^2(n_1 + n_3)/n_1 n_3} \right)^2 \]
\[ F = \frac{(19.77 - 22.79)^2}{13.66(27 + 8)/216} \]
\[ F = \frac{9.12}{478.10/216} \]
\[ F = 4.13 \]

3. Comparison of Groups I and IV
\[ F = \left( \frac{X_1 - X_4}{s_w^2(n_1 + n_4)/n_1 n_4} \right)^2 \]
\[ F = \frac{(19.77 - 24.07)^2}{13.66(27 + 8)/216} \]
\[ F = \frac{18.49}{2.21} \]
\[ F = 8.37 \]
4. Comparison of Groups II and III

\[ F = \frac{(\bar{x}_2 - \bar{x}_3)^2}{\frac{s_w^2}{n_2 + n_3}/n_2 n_3} \]

\[ F = \frac{(24.70 - 22.79)^2}{13.66(16 + 8)/126} \]

\[ F = \frac{3.65}{2.56} \]

\[ F = 1.43 \]

5. Comparison of Groups II and IV

\[ F = \frac{(\bar{x}_2 - \bar{x}_4)^2}{\frac{s_w^2}{n_2 + n_4}/n_2 n_4} \]

\[ F = \frac{(24.70 - 24.07)^2}{13.66(16 + 8)/128} \]

\[ F = \frac{.40}{2.56} \]

\[ F = .16 \]

6. Comparison of Groups III and IV

\[ F = \frac{(\bar{x}_3 - \bar{x}_4)^2}{\frac{s_w^2}{n_3 + n_4}/n_3 n_4} \]

\[ F = \frac{(22.79 - 24.07)^2}{13.66(8 + 8)/64} \]

\[ F = \frac{1.64}{3.41} \]

\[ F = .48 \]
7. Comparison of Group I with Groups II, III, and IV

\[ F = \frac{(\bar{x}_1 - \bar{x}_2 + 3 + 4)^2}{s_w^2/n_1 + s_w^2/(n_2 + n_3 + n_4)} \]

\[ F = \frac{(19.77 - 24.06)^2}{13.66/27 + 13.66/32} \]

\[ F = 18.40 \]

\[ \bar{x}_{2+3+4} = \frac{(n_2 \bar{x}_2 + n_3 \bar{x}_3 + n_4 \bar{x}_4)}{n_2 + n_3 + n_4} \]

\[ \bar{x}_{2+3+4} = (16)(24.7) + (8)(22.79) + (8)(24.07) \]

\[ \bar{x}_{2+3+4} = 24.06 \]

8. Comparison of Group II with Groups III and IV

\[ F = \frac{(\bar{x}_2 - \bar{x}_{3+4})^2}{s_w^2/n_2 + s_w^2/(n_3+n_4)} \]

\[ F = \frac{(24.70 - 23.43)^2}{13.66/16 + 13.66/16} \]

\[ F = 1.61 \]

\[ F = 1.70 \]

\[ F = .95 \]

\[ \bar{x}_{3+4} = \frac{(n_3 \bar{x}_3 + n_4 \bar{x}_4)}{8 + 8} \]

\[ \bar{x}_{3+4} = \frac{374.88}{16} \]

\[ \bar{x}_{3+4} = 23.43 \]
APPENDIX G

PARTICIPATING TEACHERS
PARTICIPATING TEACHERS FROM
THE LINCOLN PUBLIC SCHOOLS

Mrs. Florence M. Boring
Millard Lefler Junior High School
1100 South 48th Street
Lincoln, Nebraska

Mrs. Carol P. Decker
Millard Lefler Junior High School
1100 South 48th Street
Lincoln, Nebraska

Mr. Henry E. Goebel
Irving Junior High School
2745 South 22nd Street
Lincoln, Nebraska

Mr. Richard W. Goeglein
Pound Junior High School
4740 South 45th Street
Lincoln, Nebraska

Mr. C. Lonnie Johnson
Everett Junior High School
1123 C Street
Lincoln, Nebraska

Mr. Richard D. Larson
Robin Mickle Junior High School
67th and Walker Streets
Lincoln, Nebraska

Mr. George W. Lyberis
Charles Culler Junior High School
52nd and Vine Streets
Lincoln, Nebraska

Mr. John Oakes, Jr.
Everett Junior High School
1123 C Street
Lincoln, Nebraska

Mr. Fred D. Richardson
Charles Culler Junior High School
52nd and Fine Streets
Lincoln, Nebraska

Mr. Clair R. Shuman
Whittier Junior High School
2240 Vine Street
Lincoln, Nebraska

Mrs. Ruth M. Whittemore
Millard Lefler Junior High School
1100 South 48th Street
Lincoln, Nebraska

Mrs. Jacqueline Zucali
Dawes Junior High School
49th and Colfax Streets
Lincoln, Nebraska